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Empirical Evidence on Price Determination in Canada: An Aggregate Approach

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EMPIRICAL EVIDENCE ON PRICE DETERMINATION IN CANADA: AN AGGREGATE APPROACH

Inflation is in its essence a macroeconomic phenomenon, that of the gradual erosion of the purchasing power of money. It thus requires a macroeconomic explanation. An aggregate approach appears better suited for an analysis of aggregate price changes than a disaggregated one which, typically, would tend to emphasize microeconomic supply considerations at the expense of the macroeconomic explanation. From the outset, however, a distinction must be made between an aggregate price equation viewed as a model of inflation, and one viewed as a model of the dynamics of price and output adjustment to an aggregate demand shock. As a model of inflation, the price equation must encompass the determinants of both aggregate demand and aggregate supply. It will typically relate price changes to both current and anticipated changes in the money supply, since a sustained increase in the rate of monetary expansion is both a necessary and a sufficient condition (in the absence of structural changes in the rate of growth of the labour force and/or total factor productivity) for a sustained increase in the rate of inflation.

As a model of the supply response of the economy to an aggregate demand shock, the price equation becomes an aggregate supply curve; it cannot claim to "explain" inflation.[1] It does, however, focus on the most important aspect of the inflation process, its real output (and employment) implications. This is the approach followed here. Although the advantages of an aggregate approach are obvious in a model of inflation, they are less so in a model of the supply response. The search for micro theoretic foundations to the Phillips curve phenomenon (Phelps, Lucas, etc.) illustrates this. On the other hand, the covariation between aggregate prices and aggregate output is definitely a macroeconomic phenomenon, and lest it be overlooked in a disaggregated analysis because of the latter's excessive concentration on special factors, the need for an aggregate analysis, if only as a complement, is unquestionable.

In this paper, the specification and estimation of an aggregate equation for the GNE deflator is examined. Some theoretical considerations are reviewed in the first section and estimation results are presented and discussed in the second section. Rolling regression estimates are then presented in a concluding section.

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1. Indeed, there has been an increasing tendency over the past ten years to write the supply curve with output rather than prices as the variable on the left-hand side. For an early review of this tendency, the reader is referred to Laidler (1981).

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Theoretical Considerations

The aggregate approach has been championed by R.J. Gordon in several recent papers.[2] In its "modern" form, it expresses the rate of inflation ($\dot{p}$) as a function of the rate of growth of nominal spending ($\dot{y}$), the rate of growth of trend (or potential) output ($\dot{q}^*$), past rates of price changes ($b(L)\dot{p} = \Sigma\, b_i \dot{p}_{t-i}$) and the rate of capacity utilization (measured by the deviation of output (or its logarithm, q) from trend (q^*)):

$$\dot{p} = a(\dot{y}-\dot{q}^*) + b(L)\,\dot{p} + c(q-q^*) + u. \qquad (1)$$

Other influences in addition to the random disturbance term (u) can be found in different versions of this basic equation, but these are the major determinants.

This approach focuses primarily on aggregate demand as the long-run determinant of inflation; it assumes that changes in capacity output are fairly steady and sets out to explain how changes in aggregate demand are going to be absorbed between price changes and output changes in the short run.

One advantage of equation (1) over the more traditional representation:

$$\dot{p} = a'(\dot{q}-\dot{q}^*) + b'(L)\,\dot{p} + c'(q-q^*) + u' \qquad (2)$$

is that it firmly anchors inflation to its long-run determinant rather than linking it to its past behaviour and some elusive "disequilibrium" variable.

This form can be traced back to the early monetarist model of the Federal Reserve Bank of St. Louis (Andersen and Carlson, 1970). Also see Duguay, 1979. In that model, the regression of price changes on changes in nominal spending was an ingenious way to preserve a recursive ordering, given that changes in nominal spending were determined independently of price disturbances (u) by current and past changes in the money supply ($\dot{m}$) and nominal government expenditures ($\dot{g}$):

$$\dot{y} = v(L)\,\dot{m} + k(L)\,\dot{g} + u_y \qquad (3)$$

This recursive ordering — provided that the structure of the model was valid -- meant that ordinary least squares (OLS) estimates of the

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2. See Gordon (1980, 1981 and 1982), Gordon's comments on Schultze (1981), and Coe and Holtham (1983).

aggregate supply curve were unbiased.[3]

An interesting characteristic of having the rate of growth of nominal spending on the right-hand side of the aggregate supply equation is that OLS estimates are invariant to the particular renormalization adopted for estimation purposes. Thus equation (1) can equivalently be expressed as:

$$\dot{q} = \dot{q}* + (1-a)(\dot{y}-\dot{q}*) - b(L)\ \dot{p} - c(q-q*) - u, \qquad (4)$$

to highlight the fact that the aggregate supply curve involves the simultaneous determination of prices and output (for a given aggregate demand schedule). By contrast, renormalizing equation (2) as

$$\dot{q} = \dot{q}* + (1/a')\ (1-b'(L))\dot{p} - (c'/a')(q-q*) - u'/a' \qquad (5)$$

will not yield the same parameter values as equation (2).

These "advantages" however, are only real if the rate of growth of nominal spending is exogenous. This is an important issue that is not adequately addressed by Gordon. The assumption of exogenous nominal spending in this context is an assumption that nominal spending is independent of supply disturbances ($cov(\dot{y},u) = 0$). Only then will OLS produce unbiased estimates of parameters a, b, c. This means that the price elasticity of aggregate demand must be minus one. If it is less than one in absolute value, $\hat{a}$ will be biased upward, and inversely if it is greater than one. By contrast, Gordon's argument centers on the price elasticity of aggregate supply. He argues that an equation that forces all price adjustments to be explained by real variables and lagged price changes would produce results plagued with positive serial correlation if it were applied to a case where prices respond promptly and completely to changes in nominal GNP with little residual effect on real GNP. He cites the 1915-22 period in the United States as an example (Gordon, 1981). What Gordon does not seem to appreciate is that if nominal-income growth adjusts passively to inflation (say because the real demands of a war economy are incompressible or at any rate unresponsive to price increases), then the superior fit of equation (1) over equation (2) merely reflects the regression of current prices on current price disturbances.[4] Indeed, if the supply curve were so inelastic that real output did not react to changes in aggregate demand, then there would be no more point in estimating an aggregate supply curve specified as (1),

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3. Ironically, as their unconventional form gained acceptance, the St. Louis staff reverted to a more conventional one (Carlson and Hein, 1983).

4. Careful attention to the specification of supply-shift variables will reduce the magnitude of the bias by reducing the variance of the unexplained residual, but it does not eliminate the problem.

(4) or (5) than there would be in estimating equation (2). Equation (1) is not meant to give an explanation for price changes.

The argument for using equation (1) over equation (2) must stress the price-elasticity of aggregate demand. Mathematically, equations (1) and (2) are identical, with $a' = a/(1-a)$, $b'(L) = b(L)/(1-a)$, $c' = c/(1-a)$ and $u' = u/(1-a)$. But econometrically, OLS estimates of a', $\hat{a}'$, will always be less than $\hat{a}/(1-\hat{a})$. This may be because $\hat{a}'$ is biased downward, or because $\hat{a}$ is biased upward, or because both are biased. Equation (2) will produce unbiased estimates if real spending is independent of current price disturbances ($\mathrm{cov}(\dot{q},u') = 0$); this requires a zero instantaneous price elasticity of aggregate demand. Equation (1) will produce unbiased estimates if this elasticity is minus one. Short of estimating a model of aggregate demand, there is little that can be said a priori on its price elasticity and therefore on the relative merits of equation (1) vs. equation (2). Of course, a price increase will reduce the demand of an individual with fixed income, but this individual experiment cannot be transferred to the macroeconomic level where someone's cost is someone else's income.

Typically, a positive price shock will reduce aggregate demand through the real-balance or the real exchange rate channels. There may be a presumption that the income distribution effect of a price increase will generally act to reduce rather than increase aggregate demand, but this is only a presumption. The real-balance (or real-wealth) effect is due to the reduction in the real value of nominally fixed outside assets (money and government bonds); a reduction in real wealth may reduce consumption spending directly, and a reduction in real balances will raise interest rates and reduce capital expenditures. The real exchange rate (or international competitiveness) effect is due to the substitution of demand away from the more expensive domestic products in favour of cheaper foreign products when increasing domestic costs are not offset by a corresponding exchange rate depreciation; this will lead to a reduction in the current account balance and in GNP (q). The price elasticity of aggregate demand is thus likely to be negative, at least over time, provided that the supply of money is not passively accommodating price changes. But it is very unlikely that it would be minus one over the unit of time (year or quarter) chosen by the investigator. The negative response of aggregate demand to price shocks could be much larger than suggested here, however, if monetary authorities react to price increases by contracting the money supply.

This question was examined empirically (Duguay, 1979) in the context of the estimation of a St. Louis-type, reduced-form model for Canada. In the St. Louis reduced-form monetarist model, aggregate demand is assumed to have a price elasticity of minus one: nominal spending is assumed to depend exclusively on exogenously set money supply and (to a lesser extent) nominal government spending, and real spending is determined

residually from the identity $\dot{q} = \dot{y} - \dot{p}$. A variant of this model (Duguay, 1979)[5] was estimated for Canada against an alternative with a Keynesian (or neoclassical) slant, in which aggregate demand was assumed to depend on real money balances and the other autonomous spending variables. The difference between the two models, which allows one to test the St. Louis assumption of unitary price elasticity of aggregate demand, lies in the fact that the aggregate-demand response to either real or nominal money supply is spread over time. Thus, one can test whether

$$\dot{q} = v(L)\,\dot{m} + k(L)\dot{x} - \dot{p} \tag{6}$$

performs better than

$$\dot{q} = v(L)\,(\dot{m}-\dot{p}) + k(L)\dot{x}, \tag{7}$$

when $\dot{m}$ is treated as exogenous. One can also use the predicted values of $\dot{q}$ from equation (7) and the predicted values of $\dot{y}$ from equation (6) as instruments for $\dot{q}$ and $\dot{y}$ in the estimation of equations (2) and (1) respectively. Contrary to their OLS counterpart, the instrumental variable (IV) estimators of a and a' are unbiased or very nearly unbiased.[6] I found an IV estimate of a of 0.33, virtually equal to the OLS estimate of 0.31, and an IV estimate of a' of 0.30, more than four times the insignificant value of 0.07 yielded by OLS. I also found that equation (6) performed better than equation (7) in dynamic simulation over the 1969-77 period. This would seem to support Gordon's preference for equation (1).

Past price changes in equation (1) stand as a measure of both structural inertia in the pricing process (due to adjustment costs, contractual arrangements, or price imitation resulting from staggered wage contracts) and the autoregressive content of inflationary expectations. The latter will depend on the generating process of inflation and aggregate demand. (Indeed, a more general specification would allow a distributed lag on nominal income as well as on prices.) If disturbances in the rate of growth of nominal spending are regarded as transitory, b(1), the sum of b_i in equation (1), will be less than (1-a). We would

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5. Nominal aggregate demand depends on real rather than nominal fiscal variables, as well as on real exports and terms of trade (denoted as x in equations (6) and (7)).

6. A minimal bias may persist because the instrument $\hat{y}$ includes current period $\dot{m}$ (with a small coefficient of 10%), while the instrument $\hat{q}$ includes current period $(\dot{m}-\dot{p})$ (with an insignificant coefficient of less than 2%).

expect this to be the case if the rate of growth of nominal spending follows a covariance stationary process.[7] In that event, it would not be reasonable to use the estimated parameters of equation (1) to inquire about the consequences of a permanent increase or a permanent reduction in the rate of monetary expansion (Mishkin, 1979).

Such supply factors as would be revealed by a disaggregated analysis can be incorporated into this framework by the addition of supply variables (z)

$$\dot{p} = a(\dot{y}-\dot{q}^*) + b(L)\dot{p} + c(q-q^*) + dz + \varepsilon . \tag{8}$$

This method is a more valid way of measuring the macroeconomic influence of these factors than that of tracing the propagation of these influences through a structural disaggregated price model:[8]

$$\dot{p}_i = \sum_{j=1}^{n} b_{ij}\,\dot{p}_j + c_i(q_i - q_i^*) + d_i z_i, \quad i = 1,n$$

and $\dot{p} = \sum_{i=1}^{n} w_i \dot{p}_i .$

This is because the disaggregated model may inadvertently impose unwarranted constraints on some c_i and d_i. In principle, all special microeconomic factors z_i (and possibly the qs) should be included in every individual price equation. In practice, because cross effects are diffused, they will typically be small, appear statistically insignificant, and be neglected in an effort to improve statistical levels of significance. In some cases, they may be ignored rather than neglected. As a result, the implicit equation for aggregate prices

$$\dot{p} = W' \, (I-\hat{B})^{-1}(\hat{C}\,Q + \hat{D}\,Z),$$

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7. See T. Sargent (1971). If the rate of growth of nominal spending were randomly and independently distributed around a constant mean μ , and if prices adjusted instantaneously to clear markets, then we would have the aggregate supply curve

$$\dot{p} = a(\dot{y}-\dot{q}^*) + c(q-q^*) + (1-a)(\mu - \dot{q}^*),$$

the equation estimated by R. Lucas (1973).

8. For the sake of simplifying the notation let p_m to p_n represent factor costs (say, wages) and z_m to z_n include labour's price expectations ($\dot{p}^e$).

where $W' = (w_1\ w_2\ \ldots\ w_n)$,

$\hat{B} = \{\hat{b}_{ij}\}$,

$\hat{C}$, Q, $\hat{D}$ and Z are diagonal and block diagonal matrices of the

$\hat{c}_i$, q_i, $\hat{d}_i$, and z_i variables or coefficients,

will differ from the true reduced-form solution:

$$\dot{p} = W'\,(I-B)^{-1}\,(C\,Q + D\,Z), \tag{9}$$

where $C = \{c_{ij}\}$ and $D = \{d_{ij}\}$. Possible omitted variable biases in the estimation of coefficients b_{ij}, c_i and d_i are another source of discrepancy, but in general they will tend to provide a partial offset to the original misspecification ($\hat{b}_{ij}$ will typically be underestimated, and $\hat{c}_i$ and $\hat{d}_i$ will capture any correlation between q_i and z_i on the one hand and the omitted variables on the other).

There is, however, an aggregation loss in relating price changes to aggregate output only, as does equation (8), rather than to sectoral outputs, as would the reduced-form equation (9). This is because $c(q-q^*) \simeq cW'Q$ will correspond to $W'(I-B)^{-1}\,CQ$ only if $(I-B)^{-1}\,C = cI$. This can be remedied by introducing (q_i-q) among the z_i variables.

The choice of the special factors (z_i) to be incorporated in equation (8) reflects the trade-off between the contribution of these factors to an improvement in the level of statistical significance of the estimation of parameters a to c through the reduction of the noise term (ε) and their contribution to a weakening of the statistical analysis through the reduction in the number of degrees of freedom.

Equation (8) can be used to address the leading concerns of macroeconomists about the price-formation process: concerns about the cyclical sensitivity of prices, about the relative influences of the level vs. the change in the rate of capacity utilization on the trend in inflation, about the formation of expectations or, more generally, about the influence of lagged price developments; and about the stability of these factors over time.

R.J. Gordon's evidence for the United States shows a remarkable stability over time (1892-1980) of parameters a and c and a marked change in the process of formation of price expectations (b(L)) after the Korean War. Whereas b(1) is negligible before 1950, it is close to (1-a) after that, confirming the accelerationist hypothesis. Gordon's evidence differs somewhat from that of C.L. Schultze (1981) who also observed the stability of parameter a in peacetime conditions, but concluded that the effect of the output gap (c) was a postwar phenomenon and that the accelerationist hypothesis received no support from the data before 1967.

Gordon tested explicitly for structural changes in the price-formation process and found that the only significant instances of structural changes were:[9]

(i) an increase in coefficient a from 33% to 87% during and in the aftermath of World War I (1915-22), and 52% during and in the aftermath of World War II (1942-49);

(ii) a drop from 0.18 to zero in the effect of the output gap on inflation during the depression (1929-41);[10]

(iii) an increase in the coefficients of lagged prices (b(1)) from an insignificant 5% to 46% in 1950, not 1942, 1954 or 1967, which Gordon interprets as providing support for the hypothesis that the advent of the three-year overlapping staggered-wage contract in 1948 explains the greater degree of price inertia.

Gordon's interpretation of the last change is not convincing. Far from suggesting greater price inertia after 1950, his equation implies that the economy has become accelerationist or nearly money-neutral with four fifths of the changes in nominal income being ultimately reflected in prices compared to less than one half before 1942. His results are more consistent with a monetarist contention that expectations became extrapolative under a fiat money standard, because monetary policy tends to be more accommodative under such arrangements than under a gold standard.

Coe and Holtham (1983) reported regression estimates for the period 1952-81 for several O.E.C.D. countries including the United States and Canada. They found overwhelming evidence of accelerationist properties, particularly after 1970, for most countries. For the United States they reported a sharp increase (from 0.31 to 0.80) in parameter b in 1971, partially offset by a drop from (0.52 to 0.21) in parameter a. For Canada, they found an increase in coefficient a from 0.47 before 1971 to 0.80 after 1970; their estimate of the lagged price-change coefficient remained stable at 0.22. Coe and Holtham obtained systematically larger estimates of parameter a than most other researchers; they attribute this to their different estimation technique (use of IV estimator) and their different method of constructing trend output (a phase average trend method which produces a flexible estimate of trend output). They also obtained steeper estimates of the Phillips curve than most researchers as a result of their definition of trend output, with a one percentage point gap causing a 0.6 percentage point reduction in inflation in both

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9. These are taken from Gordon's comments on Schultze (1981). They differ a little from Gordon's (1980) article. In the earlier piece, Gordon reported no significant change in U.S. price behaviour during the Second World War (other than the influence of price controls) and dated the change in the process of formation of expectations as 1953 instead of 1950.

10. A zero value for parameter c indicates that there are no natural tendencies in the economy that would bring output to its trend growth path following an aggregate demand disturbance. This may be due to incorrect estimates of trend output, but it may also be telling us something about the state of the economy during the depression.

economies. (Alternatively put, about 60% of an output gap would tend to be closed each year in the absence of unexpected demand shocks.)

The Empirical Evidence for Canada

Equations (1) and (8) were estimated over various subperiods of the 1955-81 period to check the stability of the inflation process in Canada. The inflationary experience over this period can be conveniently divided into four phases (see Chart 1). From 1955 to 1961 inflation remained low (averaging 1.6%) but displayed a large quarter-to-quarter volatility; M1 growth also fluctuated sharply, falling quickly near zero after two short bouts of near 10% growth. From 1961 to 1966, inflation increased steadily as the economy recovered from the 1960 recession; over this period, M1 growth also increased quite steadily, exhibiting much less volatility than in the preceding period. From 1967 to 1970, M1 growth decreased quickly as a result of a major effort to curb the mounting inflationary pressures associated with the high rate of capacity utilization; over this period, the trend rate of inflation stabilized around a plateau of 4%. The stubbornness of inflation and the entrenchment of inflationary expectations were first recognized when inflation failed to fall with the declining rate of capacity utilization. Inflation was starting to react in 1971 (after the departure from a fixed exchange rate) when concerns over the high rate of unemployment and the rapid appreciation of the Canadian dollar led to a reversal of policy. Monetary growth soared to about 15% and was on a slow decelerating trend for the rest of the decade. This marked the beginning of the fourth phase in the postwar history of inflation. This last phase was marked by two bouts of escalating oil prices, a reduction in Canada's potential output growth and an interval with incomes control. Inflation took off in 1973-74, but declined only slightly over the decade 1973-82, in spite of the decelerating growth in the money supply. Inflationary expectations became more entrenched. The sharp fall in inflation in 1983 marks the beginning of a new phase.

The estimation period (1955-81) was subdivided into various subsamples based on the exchange rate regime (55Q1-62Q1; 62Q2-70Q2; 70Q3-81Q4) and on a more or less arbitrary division into three subsamples of equal length (55Q1-63Q4; 64Q1-72Q4; 73Q1-81Q4). The decision to end the estimation period in 1981 was based on the fact that Canada experienced her most severe contraction in the post-1950 period in 1982. We do not want it to dominate the estimation; in addition, it provides an interesting opportunity for extra-sample testing.

The regression results tabulated in Table 1 for the simple equation (1) indicate that the inflation process has changed substantially over time. For example, a dramatic change is observed in the autoregressive structure of price changes, with b(1) increasing from a large negative

(-0.85) for the 1955-61 subperiod to a large positive (0.59, just under $(1-\hat{a})$) for the 1973-81 period. We also find a large increase (from 0.07 to 0.22) in the coefficient of the gap between the 1955-63 and the 1964-81 subperiods, and a drop in coefficient a from 31% over the full sample period to only 9% during the sixties.

A Chow test reveals that these changes are statistically significant: for example, the sum of squared residuals over the three subperiods 55Q1-62Q1, 62Q2-70Q2, 70Q3-81Q4, characterized by their exchange rate regime, is 22.794 compared to 32.534 for the period as a whole, leading to an F-statistic ($F(12,90) = 3.2$) greater than the critical value of 2.4 at the 1% level.[11] F-ratios for alternative groupings are presented in Table 1A, where it can be observed that the F-ratio testing for structural breaks in 1962 and 1973 is more significant than the test for structural breaks at the time of changes in the exchange rate regime. There is, however, only weak evidence of a structural break in 1973 when the shorter 1964-81 period is considered: estimated coefficients a and b(1) are quite different between the subsamples 64Q1-72Q4 and 73Q1-81Q4, but the F-statistic at 1.9 is less than its critical value at the 5% level. This suggests that the change in the inflationary process must have proceeded gradually through the sixties.

Extra-sample statistics presented in the last two columns of Table 1 (the mean error and the root mean square error over the period 1982Q1-1983Q2) indicate that the price equation fitted for 1973Q1-1981Q4 (which does not differ materially from the equation fitted over the longer 1964Q1-1981Q4 period) overestimates greatly the effect of the 1982 recession on prices. The mean forecast error is almost 2 percentage points at quarterly rates. This is a result of the estimated value of coefficient c on the gap being extremely large: a 1% gap between actual and trend output is estimated to lower inflation by about one percentage point (annual rate).[12] This is five times the value reported by Gordon for the United States. When the equation is fitted over a longer sample period (see lines 9, 10, and 11 on Table 1) this coefficient bears most of the burden of parameter instability,[13] and it falls significantly; as it does, the forecast errors for 1982Q1-1983Q2 improve markedly. This

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11. The calculated F probably has a slight upward bias due to the presence of heteroscedasticity, as detected in the much lower variance of residuals over the 1962-70 subperiod.

12. Trend output was defined as the fitted value of real GNP regressed in logarithmic terms on a linear time trend over the 1953-81 period and on a 12-quarter moving average of a time trend starting in 1974Q1, to allow for a gradual reduction in the trend rate of growth of GNP after that date.

13. This is quite different from saying that this parameter is the unstable one. In fact, this parameter turns out to be quite stable over the 1958-81 period.

suggests that the equation's parameters have changed again during the recession.

Our findings on the stability of this price equation contrast sharply with Gordon's results for the United States. Whereas we are led to conclude that the formation of price expectations became extrapolative only gradually, under the accumulated evidence of accelerating growth in money, prices and nominal income, Gordon had no difficulty in finding accelerationist properties in the price-formation process in the United States before 1967. Gordon (1982) did, however, observe that the mean lag on past price changes had shortened significantly from 11.2 to 6.8 quarters after 1966. Thus, it could be that our lag distribution on past price increases that extend over only 6 quarters is too short. Furthermore, Gordon insisted that the influence of supply shocks (z_i) must be accounted for if the regression is to yield any reasonable estimates of parameters a, b(L) and c. We should thus turn, now, to a richer specification.

Tables 2 and 2A report the regression results and F-ratios for structural stability for equation (10):

$$\dot{p} = a(\dot{y}-\dot{q}^*) + b(L)\dot{p} + c(q-q^*) + d(L)\,(\dot{p}x-\dot{p}m) \qquad (10)$$

$$+e(L)\,\dot{p}e + f(L)\,QAIB + \varepsilon\,,$$

where px, pm and pe are the implicit national accounts deflators for merchandise exports, merchandise imports and energy consumption, and QAIB is a transitional 0-1 dummy intended to capture the effect of the imposition of incomes control from 1975Q4 to 1978Q3.

Table 3 reports some regression results for a more general specification:

$$\dot{p} = a(L)(\dot{y}-\dot{q}^*) + b(L)\dot{p} + c(q-q^*) + d(L)\,(\dot{p}x-\dot{p}m) \qquad (11)$$

$$+e(L)\,\dot{p}e + h(L)\,\dot{p}c + f(L)\,QAIB + \varepsilon\,,$$

where pc is the consumption deflator.

The reason for introducing lagged values of the consumption deflator is to capture the fact that inflationary expectations and especially wage behaviour may be primarily influenced by consumer prices rather than by the GNE deflator. That could be one reason why lagged price coefficients in equations (1) and (10) reject the accelerationist hypothesis.

Regression results presented in Table 2 use a six-quarter distributed lag on $\dot{p}$. Experiments with a longer lag structure (20 quarters) failed to yield any significant coefficients beyond lag five in most cases, and did not get us any nearer to the accelerationist results.

QAIB appears with a distributed lag (f(L)) in order to allow for a possible offsetting of the effect of lagged dependent variables and not to assume that controls had a once and for all permanent effect on inflation. It turns out that the estimated coefficients attribute a large but transitory and statistically insignificant effect to the incomes control program on inflation.

Energy prices enter the equation in nominal rather than relative terms, because we do not believe that they would react instantaneously to random disturbances in the general price level (ε), a prerequisite for the relative price formulation. The introduction of contemporaneous relative energy-price change ($\dot{p}e-\dot{p}$) in equation (10) would cause a bias due to the negative covariance between this and the error term if energy prices do not respond instantaneously to the error term. As a result of the chosen specification, the requirements of an accelerationist model become $a + b(1) + e(1) = 1$ in (10), and $a(1) + b(1) + e(1) + h(1) = 1$ in (11).

Export and import prices are introduced primarily to prevent the spurious correlation between income growth and the terms-of-trade swings of the 1970s from biasing the estimation of parameter a.[14] These swings reflected the international commodity price boom and were largely exogenous to the Canadian economy. In turn, they have greatly affected the real income of Canadians by causing wide fluctuations in the ratio of the GNE deflator to the CPI (see Freedman, 1977). It turns out that the terms-of-trade effect is very strong starting in 1962Q2, and that its inclusion stabilizes the estimated value of coefficient $\hat{a}$. In Table 1, a is observed to fall from 0.18 to 0.10 between 55Q1-62Q1 and 62Q1-70Q2 and to increase to 0.31 over the 70Q3-81Q4 interval. In Table 2, the estimated values of a are 0.12, 0.10 and 0.14 over the same periods. Even more striking is the fact that $\hat{a}$ takes on values of 0.156, 0.163 and 0.165 over the 55Q1-63Q4, 64Q1-72Q4 and 73Q1-81Q4 subperiods in Table 2, while it took values of 0.17, 0.09 and 0.36 respectively in Table 1. Except for the late fifties, when it is insignificant, the direct terms-of-trade effect (d(1)) is about 20% to 25%, corresponding to the degree of openness of the Canadian economy. Surprisingly, however, the lag distribution of the terms-of-trade coefficients does not show the reversal that one would expect as a result of the distributed lag on the dependent variable if inflationary expectations "looked through" oscillations in the terms of trade or if they were influenced primarily by movements in consumer prices.

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14. This is quite different from Dewald and Marchon's use of the average of export and import prices to capture the influence of exchange rate movements and foreign price changes on domestic price developments in a closed economy. (See Dewald and Marchon, 1979 and Marchon, 1979). We chose to ignore their specification, because it still leaves endogenous exchange rate movements unexplained.

Although the introduction of terms-of-trade changes in the equation helps to stabilize the estimated value of coefficient a, our previous conclusion regarding parameter instability in this representation of the inflationary process is not reversed with equation (10). The coefficient of the gap is very small in the fifties and, if extra-sample statistics are any indication, during the 1982 recession; evidence that price expectations switched from being regressive in the fifties to being extrapolative during the seventies also continues to be present. In addition, we find that energy prices do not make any contribution to explaining changes in inflation until their takeoff in 1973-74. The introduction of relative energy-price changes as a specific source of inflation makes the autoregressive structure of prices less favourable to the accelerationist hypothesis, as can be seen from the column labelled a/(1-b(1)-e(1)). As pointed out above, the accelerationist hypothesis requires that a+b(1)+e(1) = 1; instead, the sum of these coefficients is estimated at 0.87 (73Q1-81Q4), 0.80 (67Q1-81Q4) or even as low as 0.70 (58Q1-81Q4). This yields much lower values for a/(1-b(1)-e(1)). In the simpler equation, the sum of coefficients (a+b(1)) varied between 0.80 (58Q1-81Q4) and 0.95 (73Q1-81Q4). Furthermore, whereas the sum of a+b(1)+e(1) in equation (10) is statistically different from one for most periods other than 73Q1-81Q4, the sum of a+b(1) in the simpler equation differed statistically from one only for the 58Q1-81Q4 and 62Q2-81Q4 sample periods.

Nothing is gained from the introduction of lagged changes in consumer prices or nominal spending among the explanatory variables. The lag structure on nominal spending generally exhibits no significant coefficients beyond lag one or two, and the influence of lagged consumer prices cannot be estimated with any degree of precision; point estimates often turn up at zero. Finally, the larger number of parameters to be estimated results in greater variability in their estimated values over different estimation periods.

The effect of relating inflation to nominal spending instead of real GNE can be evaluated by comparing the regression results listed in Tables 2 and 4. In Table 4, real GNE growth is used as a regressor instead of nominal GNE growth. Its coefficient is insignificant, always less than the coefficient of the gap and often negative. The sum of b(1) and e(1) in Table 4 is also systematically smaller than the corresponding (b(1)+e(1))/(1-a) in Table 2 (0.63 vs. 0.85 for the subperiod 73Q1-81Q4, 0.70 vs. 0.76 for the period 67Q1-81Q4, 0.63 vs. 0.65 for the period 58Q1-81Q4).

It is suggestive that when a six-quarter polynomial distributed lag on the gap is substituted for regressors $(\dot{q}-\dot{q}^*)$ and $(q-q^*)$, the current value coefficient is generally quite significant, and often larger than lagged coefficients (see Table 5). This suggests that coefficient a' in Table 4 may be biased due to a negative feedback of $\dot{p}$ on $\dot{q}$. This negative

feedback can be due to the price elasticity of aggregate demand, as pointed out above, or to monetary-policy reaction, or again to errors in variables due to the method of deflating nominal spending in the national accounts. To minimize the latter, we also ran our regressions with chain-linked indices of $\dot{p}$ and $\dot{q}$ compiled by our colleague G. Meredith, but this did not make much difference to the results.[15]

Concluding Comments

The econometric results obtained with an aggregate price equation similar to Gordon's are on the whole rather disappointing. They point to a much steeper short-run Phillips curve in Canada than in the United States and a much smaller degree of inertia in the price-formation-process, two conclusions that one would not intuitively draw from Canada's poor inflation performance since 1972. They also exhibit strong evidence of parameter instability. This suggests that a more systematic examination of the actual behaviour of these parameters than is contained in Tables 1 through 5 is required.

Rolling regressions of fixed thirty-six-quarter length were performed over the 1953Q1 - 1983Q4 period with a parsimonious version of equation (10):

$$\dot{p} = a(\dot{y}-\dot{q}^*) + \sum_{i=1}^{4} b_i L^i \dot{p} + cL(q-q^*) + d(\dot{p}x-\dot{p}m) + u \qquad (12)$$

$$u_t = \rho u_{t-1} + \varepsilon_t,$$

where the autocorrelation coefficient (ρ) was constrained to -0.3, based on preliminary investigation. It was found that allowing for autocorrelation stabilized the autoregressive parameter b_1. Stepwise Chow tests were also conducted over the 1958Q1-1981Q4 and 1961Q1-1979Q4 periods. These tests suggest that structural breaks may have occurred in 1961Q2 and 1968Q1. The test conducted over the longer period exhibited a jump in the F-ratio from 1.7 to 3.4 at 1961Q1 and peaks of 4.1 and 4.2 in 1964Q1 and 1968Q1, respectively. The same test conducted over the shorter period yielded peaks in the F-ratio at 4.7 in 1968Q1 and in 1972Q2.

Moving regression coefficients are plotted on Charts 2 to 5, and the estimated variance of the residuals is plotted on Chart 6. Evidence of distortions in the early years of the sample period (1955-56) is discernible in the sharp movement of coefficients a and c and in the

15. Somewhat counter-intuitively, the standard errors of regression were larger for the chain-linked index than for the official Paasche index.

variance of the residuals as the sample period is moved from 1955Q1-1963Q4 to 1957Q1-1965Q4.

Coefficient a, which governs the short-run split of nominal spending between price and real activity, normally lies between 0.15 and 0.21. It tends to stand at the lower end of this range in the late fifties (samples 56Q4-65Q3 to 59Q4-68Q3) and the late sixties (samples 64Q1-72Q4 to 69Q1-77Q4), and at the upper end in the second half of the seventies (69Q3-78Q2 to 72Q4-81Q3). It falls sharply below that range over the first half of the sixties, however, (to a low of 0.067 for the 62Q2-71Q1 sample period) and when 1982 is added to the estimation period.

The sum of coefficients on lagged prices reaches a high of 0.78 over the 57Q4-66Q3 sample period, but on average it remains near zero for sample periods ending before 1972Q3. It then escalates steadily to a plateau of 0.6 as the sample period is moved to include the 1973-74 inflation outburst. It remains fairly steady between 0.6 and 0.75 for all sample periods ending later than 1974Q3, after an initial distortion caused by the 74Q2 and 74Q3 price increases which sent it to 0.89, causing the sum of a+b(1) to exceed one.

The coefficient of the gap varies between 0.11 and 0.17 from 59Q1-67Q4 to 72Q4-81Q3. It drops markedly, however, when the sample period is moved back in the fifties or moved forward to include the 1982 recession. It reaches a minimum for the 56Q4-65Q3 and 73Q4-82Q3 samples. Some pickup is gradually recorded when the sample period is moved forward to include the 1983 experience. Finally, the terms-of-trade coefficient (d) tends to be quite small in the first part of the sample period, but varies between 0.12 and 0.19 from 1962 to 1983. It takes off temporarily, to a high of 0.30, when the sample period is moved from 63Q3-72Q2 to 65Q1-73Q4, but quickly stabilizes as the sample period is moved to include 1974 developments.

The results from the rolling regression analysis are thus consistent with the interpretation that parameter changes may be due primarily to changes in economic agents' perceptions of the persistence of price movements, and they suggest that a variable coefficient regression technique would be more appropriate to capture these changes.

A plot of the quarterly growth rate of the GNE deflator for the 1955Q1-1983Q4 period and its predicted value calculated from equation (11) is presented on Chart 7. It is noteworthy that systematic under-predictions of inflation are recorded in the 1961-63 and 1981-82 periods, when the GNP gap is largest.[16] This suggests that a non-linear specification of the relationship between the gap and inflation might prove useful. Also noteworthy is the fact that the prediction error essentially vanishes in 1983.

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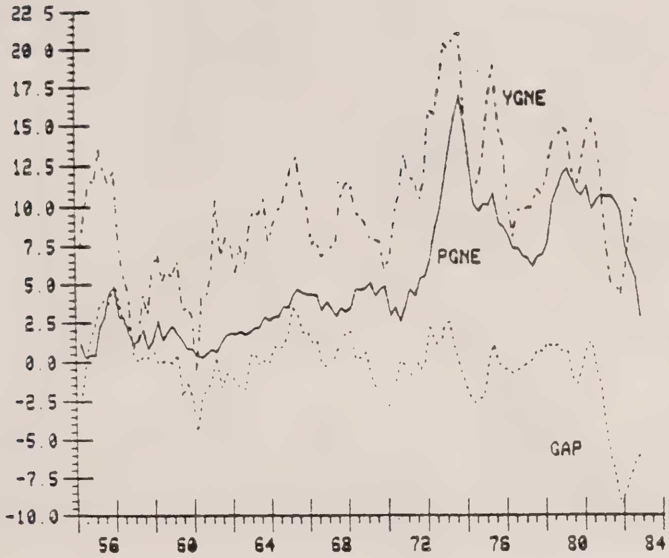
16. The large residual (blip) in 60Q1 appears to be related to adjustment entries that Statistics Canada introduced in the national accounts. No such positive blip is recorded in any of the individual deflators.

CHART 1

Four-Quarter Growth Rates of
Nominal GNE and GNE Deflator,
and GAP Between Actual and Trend Real GNE



Four-Quarter Growth Rates
of M1 and GNE Deflator

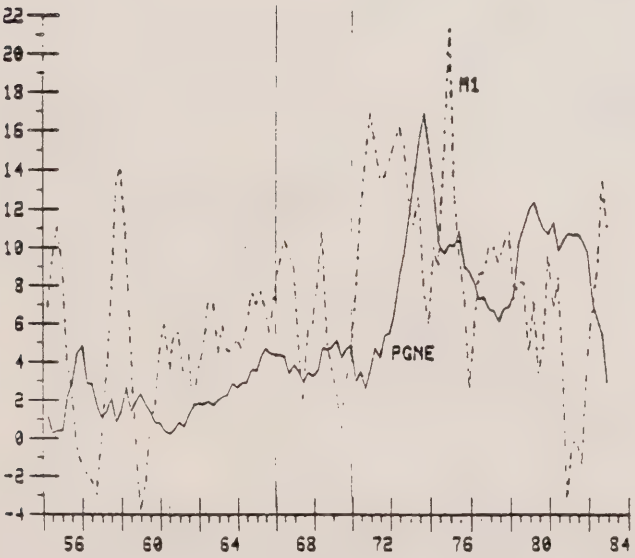


CHART 2

NOMINAL SPENDING COEFFICIENT

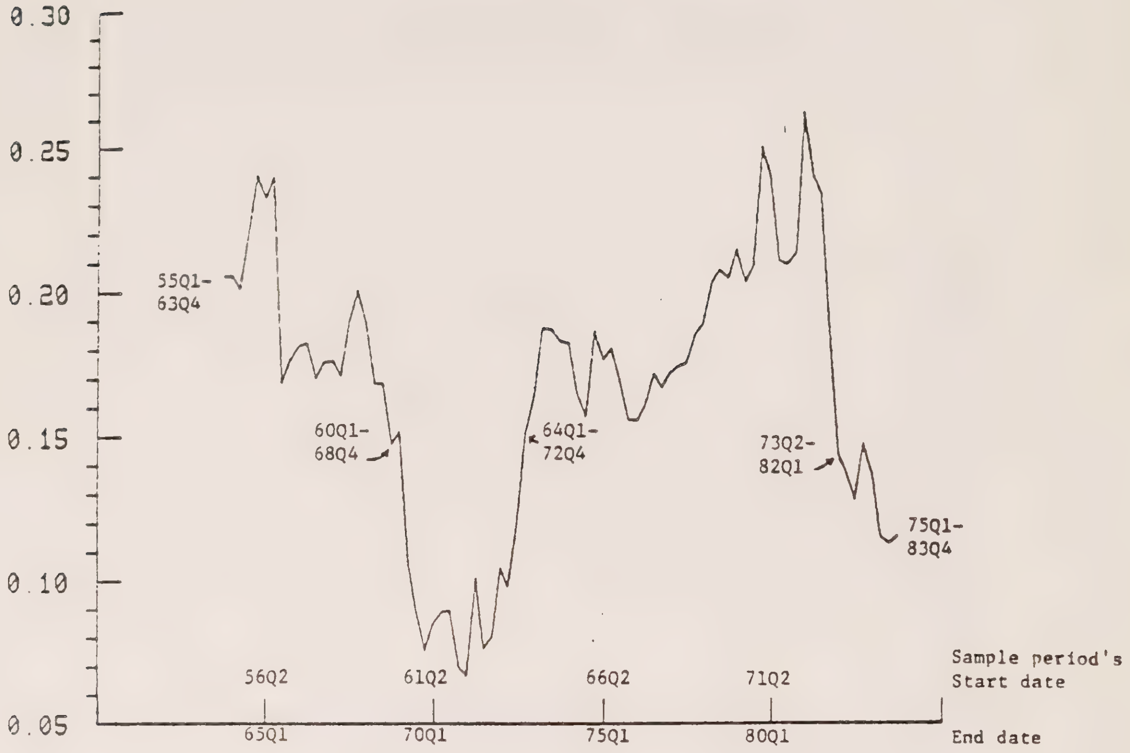


CHART 3

LAGGED PRICES COEFFICIENTS (B1 VS (B1+B2+B3+B4))

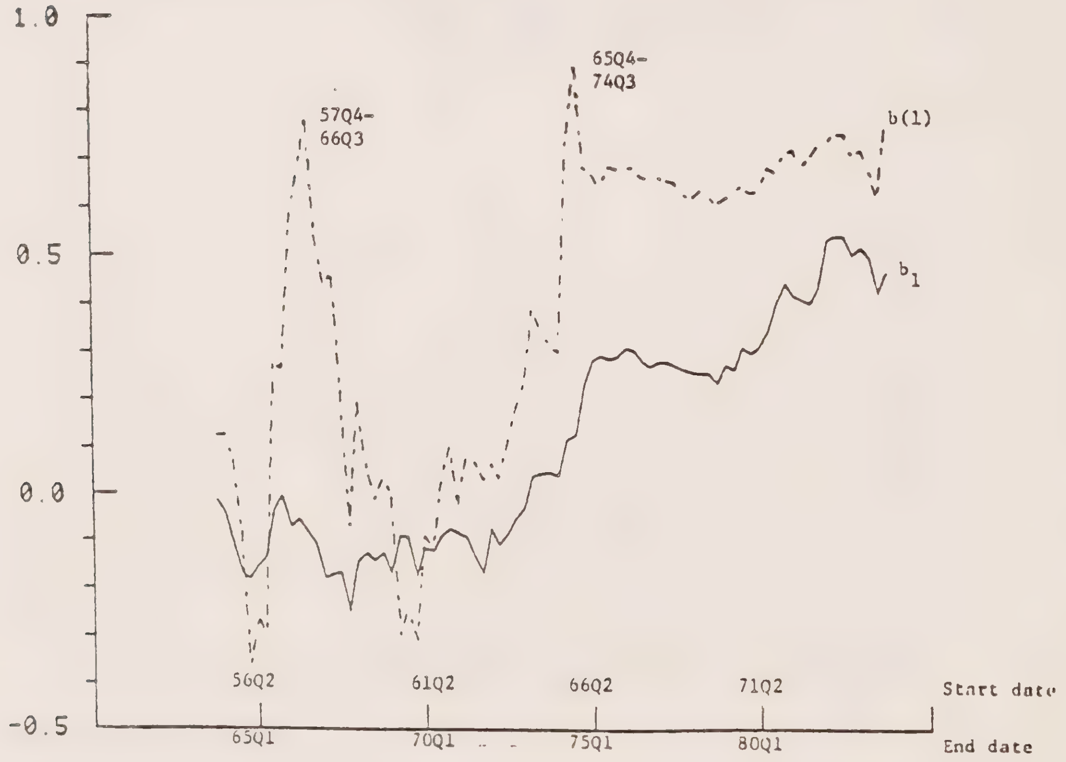


CHART 4

COEFFICIENT OF THE GAP

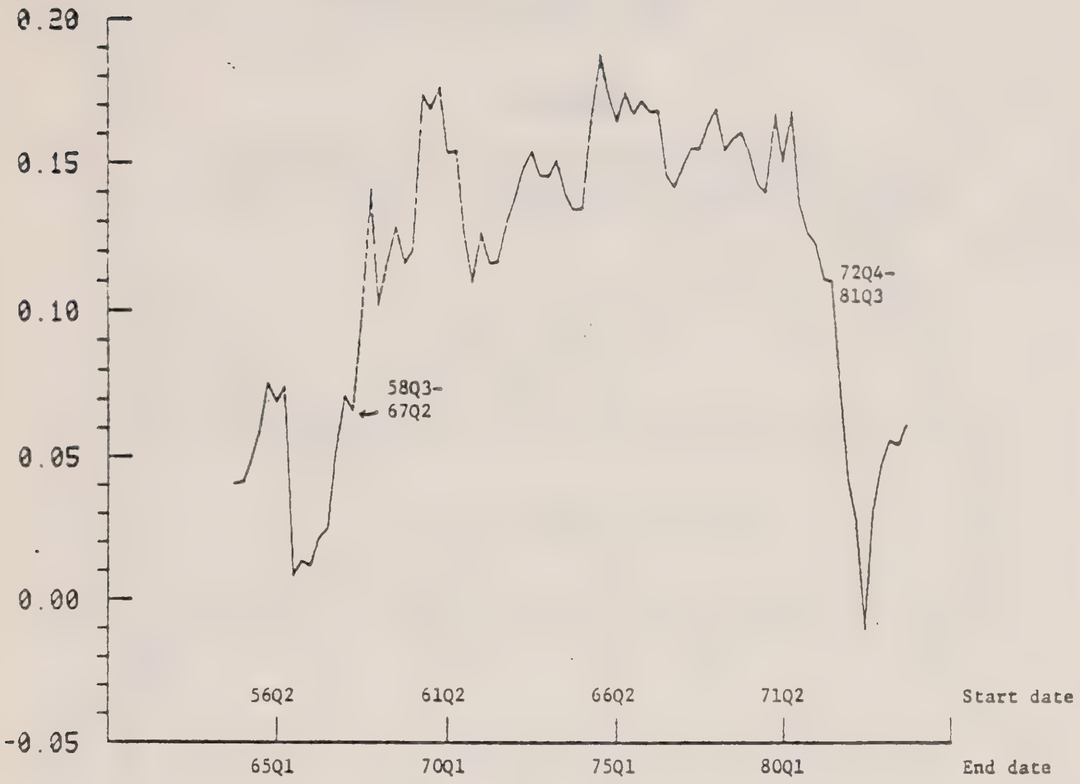
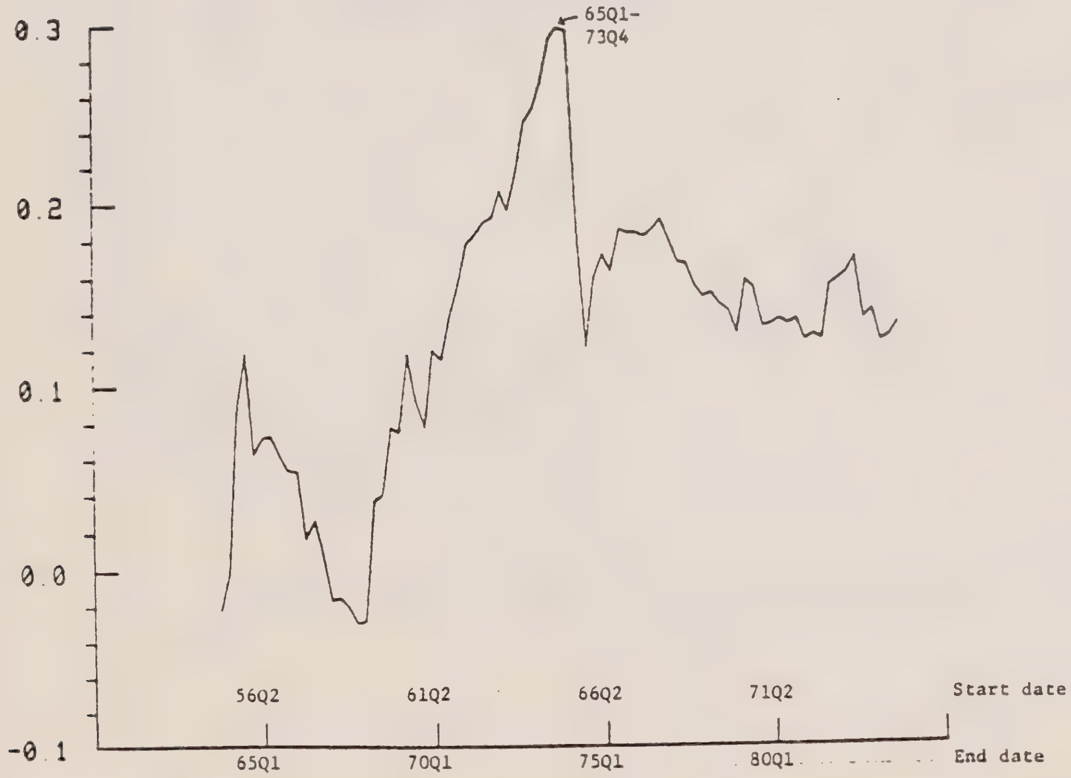


CHART 5

TERMS-OF-TRADE COEFFICIENT



<u>CHART 6</u>

Residual Sum of Squares from Moving Regression
(length 36 quarters) over sample 1955Q1 - 1983Q4

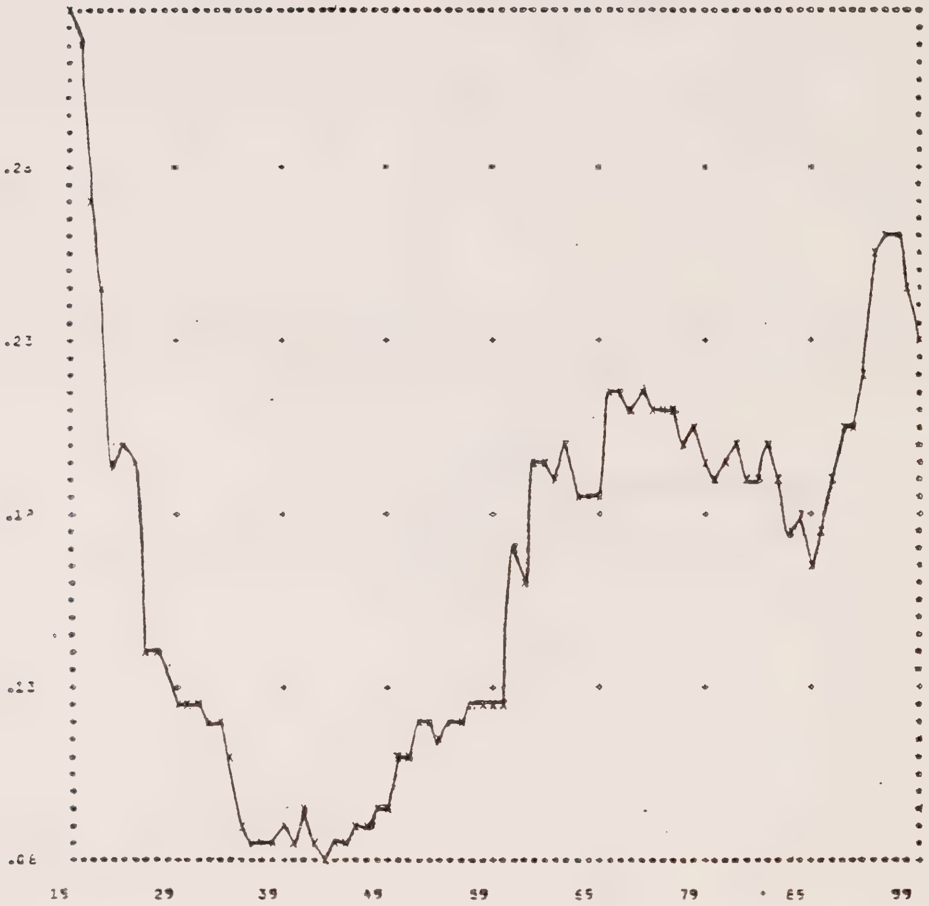
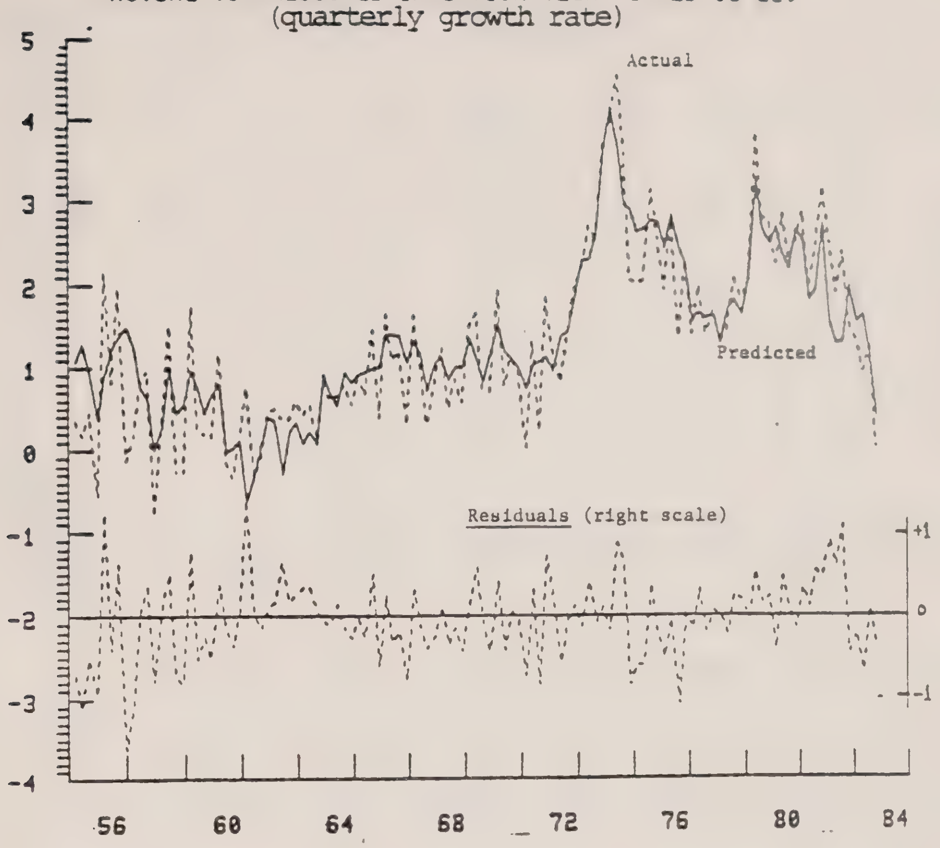


CHART 7

ACTUAL VS PREDICTED INFLATION (EQN FITTED 58-81)
(quarterly growth rate)



ACTUAL VS PREDICTED INFLATION (EQN FITTED 68-81)
(quarterly growth rate)

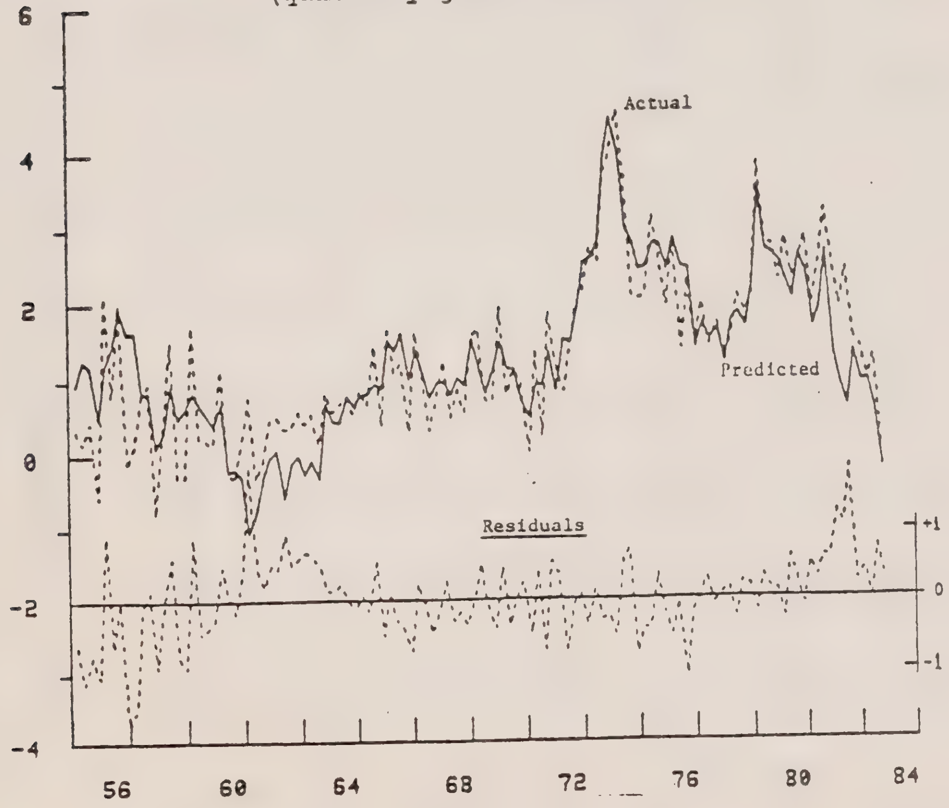


Table 1

$\dot{p} = \pi + a \ (\dot{y}-\dot{q}^*) + c \ L(q-q^*) + b(L)\ \dot{p}$

	Estimated Coefficients (standard error in parentheses)											Summary statistics: Intra-sample					1982Q1-1983Q2	
	π	a	c	b(1)*	b_1	b_2	b_3	b_4	b_5	b_6	a /(1-b(1))	Mean (std. dev)	$\bar{R}^2$	see	DW	SSR	ME	RMSE
1. 55Q1-62Q1 (29)	0.688 (0.317)	0.176 (0.090)	0.093 (0.042)	-0.854 (0.675)	-0.40 (0.18)	-0.15 (0.14)	-0.01 (0.16)	0.02 (0.15)	-0.06 (0.13)	-0.25 (0.16)	0.095 (.073)	0.422 (0.745)	0.356	0.598	2.0	8.230	-	-
2. 55Q1-63Q4 (36)	0.703 (0.261)	0.171 (0.070)	0.071 (0.032)	-0.751 (0.542)	-0.35 (0.15)	-0.11 (0.12)	0.01 (0.13)	0.03 (0.13)	-0.06 (0.11)	-0.27 (0.14)	0.098 (.059)	0.431 (0.673)	0.342	0.546	2.0	8.948	-	-
3. 62Q2-70Q2 (33)	1.411 (0.344)	0.096 (0.063)	0.200 (0.055)	-0.544 (0.373)	-0.50 (0.17)	-0.16 (0.11)	0.04 (0.11)	0.12 (0.11)	0.07 (0.09)	-0.12 (0.16)	0.062 (.044)	0.847 (0.466)	0.496	0.331	2.2	2.951	-	-
4. 64Q1-72Q4 (36)	1.190 (0.385)	0.094 (0.081)	0.229 (0.056)	-0.231 (0.380)	-0.40 (0.17)	-0.11 (0.10)	0.07 (0.11)	0.15 (0.10)	0.11 (0.09)	-0.04 (0.15)	0.076 (.074)	0.990 (0.510)	0.356	0.409	2.0	5.017	-	-
5. 73Q1-81Q4 (36)	0.026 (0.567)	0.357 (0.085)	0.231 (0.099)	0.591 (0.174)	0.16 (0.13)	0.12 (0.05)	0.09 (0.06)	0.08 (0.07)	0.07 (0.06)	0.07 (0.12)	0.873 (.444)	2.482 (0.785)	0.521	0.543	1.5	8.843	1.814	1.851
6. 70Q3-81Q4 (46)	0.206 (0.259)	0.311 (0.071)	0.248 (0.070)	0.560 (0.111)	0.12 (0.11)	0.11 (0.05)	0.10 (0.06)	0.09 (0.06)	0.08 (0.05)	0.07 (0.10)	0.707 (.210)	2.181 (0.943)	0.673	0.539	1.8	11.613	1.867	1.902
7. 67Q1-81Q4 (60)	(0.186 (0.171)	0.304 (0.059)	0.273 (0.061)	0.569 (0.089)	0.08 (0.10)	0.10 (0.04)	0.11 (0.05)	0.11 (0.05)	0.09 (0.04)	0.07 (0.09)	0.705 (.157)	1.912 (0.987)	0.731	0.512	1.8	14.174	2.036	2.071
8. 64Q1-81Q4 (72)	0.224 (0.140)	0.310 (0.054)	0.218 (0.050)	0.554 (0.081)	0.11 (0.09)	0.12 (0.04)	0.11 (0.05)	0.10 (0.05)	0.08 (0.04)	0.04 (0.08)	0.695 (.134)	1.736 (0.996)	0.749	0.499	1.9	16.450	1.639	1.674
9. 62Q2-81Q4 (79)	0.324 (0.136)	0.280 (0.050)	0.145 (0.039)	0.550 (0.080)	0.17 (0.09)	0.14 (0.04)	0.12 (0.05)	0.08 (0.05)	0.04 (0.03)	-0.04 (0.08)	0.622 (.122)	1.624 (1.020)	0.757	0.502	2.0	18.427	1.059	1.113
10. 58Q1-81Q4 (96)	0.386 (0.116)	0.272 (0.044)	0.134 (0.032)	0.525 (0.076)	0.09 (0.08)	0.15 (0.04)	0.16 (0.05)	0.13 (0.05)	0.06 (0.03)	-0.06 (0.07)	0.573 (.097)	1.397 (1.079)	0.766	0.522	2.0	24.481	0.968	1.027
11. 55Q1-81Q4 (108)	0.140 (0.096)	0.308 (0.043)	0.069 (0.025)	0.613 (0.070)	0.11 (0.08)	0.17 (0.03)	0.18 (0.04)	0.15 (0.04)	0.07 (0.03)	-0.07 (0.07)	0.796 (.135)	1.301 (1.091)	0.732	0.565	2.1	32.534	0.493	0.687

* Second degree Almon Lag with no head or tail constraint.

Table 1A

F Tests for Structural Changes (Equation 1)

Selected groupings:	Numerator	Denominator	F ratio	Critical F
55Q1-62Q1; 62Q2-70Q2; 70Q3-81Q4	9.740/12	22.794/90	3.20	2.39 (1%)
55Q1-62Q1; 62Q2-81Q4	5.877/6	26.657/96	3.00	3.00 (1%)
62Q2-70Q2; 70Q3-81Q4	3.863/6	14.564/67	2.96	3.08 (1%)
55Q1-63Q4; 64Q1-72Q4; 73Q1-81Q4	9.726/12	22.808/90	3.20	2.39 (1%)
55Q1-63Q4; 64Q1-81Q4	7.136/6	25.398/96	4.49	3.00 (1%)
64Q1-72Q4; 73Q1-81Q4	2.590/6	13.860/60	1.87	2.25 (5%)
55Q1-62Q1; 62Q2-72Q4; 73Q1-81Q4	10.259/12	22.275/90	3.45	2.39 (1%)
62Q2-72Q4; 73Q1-81Q4	4.382/6	14.045/67	3.48	3.08 (1%)
58Q1-72Q4; 73Q1-81Q4	5.974/6	18.507/84	4.52	3.03 (1%)
58Q1-70Q2; 70Q3-81Q4	6.091/6	18.390/84	4.64	3.03 (1%)
58Q1-66Q4; 67Q1-81Q4	6.185/6	18.296/84	4.73	3.03 (1%)

Table 2A

F Tests for Structural Changes (Equation 10)

Selected groupings:	Numerator	Denominator	F ratio	Critical F
55Q1-62Q1; 62Q2-70Q2; 70Q3-81Q4	8.694/22	13.741/72	2.07	2.10 (1%)
55Q1-62Q1; 62Q2-81Q4	5.878/11	16.557/83	2.68	2.47 (1%)
62Q2-70Q2; 70Q3-81Q4	2.816/11	6.438/54	2.15	1.97 (5%)
55Q1-63Q4; 64Q1-72Q4; 73Q1-81Q4	9.035/22	13.400/72	2.21	2.10 (1%)
55Q1-63Q4; 64Q1-81Q4	6.868/11	15.567/83	3.33	2.47 (1%)
64Q1-72Q4; 73Q1-81Q4	2.167/11	5.265/47	1.76	2.00 (5%)
55Q1-62Q1; 62Q2-72Q4; 73Q1-81Q4	9.126/22	13.309/72	2.24	2.10 (1%)
62Q2-72Q4; 73Q1-81Q4	3.248/11	6.006/54	2.66	2.60 (1%)
58Q1-72Q4; 73Q1-81Q4	2.870/11	11.108/71	1.67	1.93 (5%)
58Q1-70Q2; 70Q3-81Q4	3.430/11	10.548/71	2.10	1.93 (5%)
58Q1-66Q4; 67Q1-81Q4	4.806/11	9.172/71	3.38	2.51 (1%)

Table 4A

F Tests for Structural Changes

Selected groupings:	Numerator	Denominator	F ratio
55Q1-62Q1; 62Q2-70Q2; 70Q3-81Q4	12.702/22	14.669/72	2.83
55Q1-62Q1; 62Q2-81Q4	9.354/11	18.017/83	3.92
62Q2-70Q2; 70Q3-81Q4	3.348/11	7.368/54	2.23
55Q1-63Q4; 64Q1-72Q4; 73Q1-81Q4	11.803/22	15.568/72	2.48
55Q1-63Q4; 64Q1-81Q4	8.912/11	18.459/83	3.64
64Q1-72Q4; 73Q1-81Q4	2.891/11	6.466/47	1.91
55Q1-62Q1; 62Q2-72Q4; 73Q1-81Q4	13.062/22	14.309/72	2.99
62Q2-72Q4; 73Q1-81Q4	3.708/11	7.008/54	2.60
58Q1-72Q4; 73Q1-81Q4	3.369/11	12.650/71	1.72
58Q1-70Q2; 70Q3-81Q4	3.893/11	12.126/71	2.07
58Q1-66Q4; 67Q1-81Q4	4.797/11	11.222/71	2.76

Table 2

$\dot{p} = \pi + a\ (y-\dot{q}^*) + c\ \ L(q-q^*) + b(L)\ \dot{p} + d(L)(\dot{p}x-\dot{p}m) + e(L)\ \dot{p}e + f(L)QAIB$

	Estimated coefficients (standard error in parentheses)										Summary statistics: Intra-sample					1982Q1-1983Q2	
	π	a	c	$b(1)$*	$e(1)$**	d_0	d_1	f_0	$f(1)$***	$a/(1-b(1)-e(1))$	$\bar{R}^2$	see	DW	SSR	Chow F	ME	RMSE
1. 55Q1-62Q1	0.847	0.121	0.105	-1.189	0.081	-0.001	-0.021	-	-	0.057	0.270	0.637	2.1	7.303		-	-
	(0.362)	(0.112)	(0.50)	(0.772)	(0.423)	(0.121)	(0.114)			(.066)							
2. 55Q1-63Q4	0.794	0.156	0.075	-0.985	0.049	-0.011	-0.076	-	-	0.081	0.282	0.570	2.3	8.135		-	-
	(0.285)	(0.080)	(0.034)	(0.560)	(0.328)	(0.094)	(0.086)			(.053)							
3. 62Q2-70Q2	1.294	0.098	0.209	-0.208	-0.319	0.125	0.024	-	-	0.064	0.633	0.282	2.1	1.751		-	-
	(0.359)	(0.058)	(0.057)	(0.404)	(0.208)	(0.056)	(0.059)			(.044)							
4. 64Q1-72Q4	0.789	0.163	0.199	0.249	-0.208	0.253	0.020	-	-	0.170	0.684	0.287	2.3	2.053		-	-
	(0.292)	(0.57)	(0.045)	(0.291)	(0.175)	(0.057)	(0.069)			(.090)							
5. 73Q1-81Q4	0.128	0.165	0.173	0.509	0.198	0.143	0.087	-1.178	-0.155	0.563	0.763	0.382	2.3	3.212		0.931	0.931
	(0.560)	(0.078)	(0.079)	(0.183)	(0.065)	(0.036)	(0.046)	(0.845)		(.444)							
6. 70Q3-81Q4	0.378	0.136	0.200	0.422	0.210	0.146	0.097	-1.079	-0.245	0.370	0.835	0.383	2.5	4.687	1.01	0.923	1.038
	(0.211)	(0.062)	(0.059)	(0.121)	(0.060)	(0.033)	(0.042)	(0.828)		(.184)							
7. 67Q1-81Q4	(0.314	0.148	0.215	0.442	0.206	0.153	0.101	-1.083	-0.248	0.420	0.870	0.355	2.3	5.813	0.53	1.002	1.119
	(0.132)	(0.050)	(0.048)	(0.102)	(0.055)	(0.029)	(0.036)	(0.761)		(.151)							
8. 64Q1-81Q4	0.323	0.178	0.171	0.424	0.199	0.161	0.095	-1.088	-0.210	0.464	0.871	0.358	2.4	7.432	1.07	0.709	0.873
	(0.117)	(0.045)	(0.040)	(0.102)	(0.054)	(0.027)	(0.035)	(0.765)		(.133)							
9. 62Q2-81Q4	0.412	0.144	0.090	0.414	0.203	0.172	0.083	-0.971	-0.109	0.368	0.863	0.377	2.3	9.254	2.03	0.121	0.592
	(0.119)	(0.045)	(0.032)	(0.107)	(0.056)	(0.028)	(0.035)	(0.805)		(.122)							
10. 58Q1-81Q4	0.485	0.141	0.093	0.309	0.252	0.158	0.108	-0.745	-0.072	0.320	0.854	0.413	2.2	13.978	1.63	0.174	0.512
	(0.108)	(0.040)	(0.028)	(0.110)	(0.058)	(0.029)	(0.035)	(0.871)		(.092)							
11. 55Q1-81Q4	0.306	0.195	0.063	0.375	0.229	0.151	0.080	-1.020	-0.094	0.494	0.799	0.489	2.1	22.435	4.13	0.005	0.534
	(0.098)	(0.043)	(0.022)	(0.118)	(0.067)	(0.031)	(0.037)	(1.018)		(.121)							

* Second degree Almon lag of order six with no head or tail constraint.

** Second degree Almon lag of order four with no head or tail constraint.

Table 3

$\dot{p} = \pi + a(L)\ (\dot{y}-\dot{q}^*) + cL(q-q^*) + b(L)\ \dot{p} + d(L)\ (\dot{p}x-\dot{p}m) + e(L)\ \dot{p}e + h(L)\ \dot{p}c + f(L)\ QAIB$

	Estimated coefficients (standard errors in parentheses)											Summary statistics: Intra-sample				1982Q1-1983Q2	
	π	c	a	a(1)*	b(1)*	d(1)***	e(1)**	h(1)*	fo	f(1)	a(1)+b(1) +e(1)+h(1)	$\bar{R}^2$	see	DW	SSR	ME	RMSE
1. 73Q1-81Q4	0.537 (0.991)	0.234 (0.154)	0.048 (0.107)	-0.426 (0.656)	0.858 (0.571)	0.299 (0.073)	0.269 (0.133)	-0.050 (0.708)	-1.804 (1.030)	-0.251	0.663 (.510)	0.815	0.405	2.5	4.437	0.816	0.958
2. 70Q3-81Q4	0.583 (0.339)	0.255 (0.114)	0.048 (0.072)	-0.260 (0.376)	0.601 (0.359)	0.286 (0.063)	0.234 (0.093)	0.087 (0.394)	-1.596 (0.946)	-0.251	0.663 (.187)	0.815	0.405	2.5	4.437	0.816	0.959
3. 67Q1-81Q4	0.307 (0.167)	0.194 (0.077)	0.107 (0.050)	0.141 (0.251)	0.457 (0.283)	0.279 (0.053)	0.209 (0.080)	-0.001 (0.304)	-1.455 (0.870)	-0.250	0.806 (.124)	0.853	0.379	2.3	5.878	0.819	0.959
4. 62Q2-81Q4	0.198 (0.160)	0.042 (0.037)	0.134 (0.041)	0.394 (0.181)	0.277 (0.262)	0.275 (0.048)	0.143 (0.076)	0.085 (0.281)	-1.164 (0.852	-0.130	0.899 (.118)	0.863	0.378	2.3	8.567	0.135	0.640
5. 58Q1-81Q4	0.390 (0.130)	0.062 (0.031)	0.113 (0.038)	0.266 (0.135)	0.192 (0.268)	0.284 (0.048)	0.197 (0.079)	0.117 (0.283)	-0.755 (0.913)	-0.042	0.772 (.109)	0.850	0.418	2.1	13.470	0.192	0.578
6. 55Q1-81Q4	0.202 (0.111)	0.024 (0.026)	0.148 (0.041)	0.506 (0.134)	-0.169 (0.287)	0.252 (0.051)	0.131 (0.087)	0.467 (0.308)	-0.962 (1.06)	-0.223	0.935 (.105)	0.798	0.491	2.1	21.419	0.008	0.515
7. 62Q2-70Q2	0.983 (0.831)	0.189 (0.118)	0.085 (0.065)	0.262 (0.416)	-0.719 (0.713)	0.261 (0.106)	-0.757 (0.321)	1.131 (0.571)	-	-	-0.083 (.904)	0.604	0.293	2.1	1.459		
8. 62Q2-72Q4	0.208 (0.590)	0.070 (0.083)	0.109 (0.054)	0.543 (0.344)	-0.027 (0.441)	0.189 (0.096)	-0.495 (0.223)	-0.807 (0.461)	-	-	0.829 (.619)	0.648	0.303	2.1	2.480		
9. 58Q1-66Q4	0.913 (0.494)	0.110 (0.068)	0.119 (0.053)	0.405 (0.217)	-0.781 (0.716)	0.054 (0.106)	0.304 (0.276)	0.208 (0.666)	-	-	0.136 (.753)	0.605	0.347	2.2	2.404		

* Second degree Almon lag of order six (starting in period t for a but t-1 for b and h) with no head or tail constraint.
** Second degree Almon lag of order four (starting in period t) with no head or tail.
*** Freely estimated two-period lag; standard error not available, approximated as the geometric average of the standard errors of do and d1.

Table 4

$\dot{p} = \pi + a'(\dot{q}-\dot{q}^*) + c'\,L(q-q^*) + b'(L)\,p + d'(L)(\dot{p}x-\dot{p}m) + e'(L)\,\dot{p}e + f'(L)QAIB$

	Estimated coefficients (standard error in parentheses)										Summary statistics: Intra-sample				1982Q1-1983Q2	
	π	a'	c'	$b'(1)$*	$e'(1)$**	d'_0	d'_1	f'_0	$f'(1)$	$b'(1)+e'(1)$	$\bar{R}^2$	see	DW	SSR	ME	RMSE
1. 55Q1-62Q1	1.297 (0.342)	-0.122 (0.112)	0.131 (0.046)	-1.772 (0.706)	0.084 (0.423)	0.054 (0.121)	0.018 (0.114)	-	-	-1.688 (.780)	0.270	0.637	2.5	7.301	-	-
2. 55Q1-63Q4	1.156 (0.298)	-0.056 (0.089)	0.088 (0.035)	-1.392 (0.567)	0.088 (0.347)	0.078 (0.091)	-0.069 (0.092)	-	-	-1.304 (.664)	0.196	0.603	2.5	9.102	-	-
3. 62Q2-70Q2	1.758 0.425)	0.016 (0.066)	0.222 (0.060)	-0.343 (0.426)	-0.285 (0.224)	0.138 (0.058)	0.027 (0.063)	-	-	-0.628 (.408)	0.586	0.300	2.2	1.974	-	-
4. 64Q1-72Q4	1.346 (0.333)	0.055 (0.077)	0.211 (0.056)	0.120 (0.353)	-0.203 (0.211)	0.253 (0.073)	-0.006 (0.082)	-	-	-0.083 (.324)	0.600	0.322	2.3	2.597	-	-
5. 73Q1-81Q4	0.902 (0.583)	0.006 (0.097)	0.139 (0.091)	0.412 (0.216)	0.218 (0.071)	0.158 (0.039)	0.125 (0.047)	-1.124 (0.938)	-0.248	0.630 (.229)	0.714	0.419	2.6	3.869	0.276	0.573
6. 70Q3-81Q4	0.828 (0.238)	-0.007 (0.073)	0.192 (0.065)	0.407 (0.135)	0.246 (0.062)	0.165 (0.034)	0.125 (0.043)	-0.916 (0.897)	-0.197	0.653 (.105)	0.810	0.411	2.5	5.394	0.711	0.899
7. 67Q1-81Q4	0.714 (0.156)	0.013 (0.061)	0.209 (0.055)	0.446 (0.115)	0.255 (0.057)	0.177 (0.030)	0.129 (0.038)	-0.918 (0.837)	-0.170	0.701 (.081)	0.846	0.388	2.4	6.923	0.822	1.005
8. 64Q1-81Q4 (72)	0.691 (0.149)	0.033 (0.058)	0.171 (0.046)	0.434 (0.117)	0.258 (0.058)	0.189 (0.030)	0.126 (0.038)	-0.910 (0.865)	-0.027	0.692 (.079)	0.838	0.402	2.4	9.357	0.555	0.786
9. 62Q2-81Q4 (79)	0.646 (0.147)	-0.010 (0.053)	0.084 (0.035)	0.410 (0.117)	0.255 (0.058)	0.198 (0.029)	0.110 (0.037)	-0.733 (0.871)	-0.008	0.665 (.078)	0.841	0.406	2.3	10.716	-0.054	0.591
10. 58Q1-81Q4 (96)	0.656 (0.138)	-0.017 (0.047)	0.083 (0.030)	0.331 (0.118)	0.303 (0.061)	0.189 (0.030)	0.130 (0.037)	-0.545 (0.935)	-0.043	0.634 (.075)	0.832	0.442	2.1	16.019	-0.048	0.531
11. 55Q1-81Q4 (108)	0.503 (0.115)	-0.021 (0.053)	0.055 (0.025)	0.389 (0.131)	0.300 (0.072)	0.195 (0.033)	0.122 (0.040)	-0.828 (1.128)	0.054	0.689 (.078)	0.755	0.540	2.1	27.371	-0.239	0.587

* Second degree Almon Lag of order six with no head or tail constraint.
** Second degree Almon lag of order four with no head or tail constraint.

Table 5

$\dot{p} = \pi + c'(L)(\dot{q}-\dot{q}^*) + b'(L)\ p + d'(L)(\dot{p}x-\dot{p}m) + e'(L)\ \dot{p}e + f'(L)QAIB$

	Estimated coefficients (standard error in parentheses)									Summary statistics: Intra-sample				Summary statistics: 1982Q1-1983Q2	
	π	c	c(1)*	b(1)*	d(1)***	e(1)**	fo	f(1)	b(1)+e(1)	$\bar{R}^2$	see	DW	SSR	ME	RMSE
1. 55Q1-81Q4	0.375	0.012	0.032	0.469	0.306	0.276	-0.689	-0.013	0.745	0.759	0.536	2.2	26.676	-0.158	0.538
	(0.114)	(0.034)	(0.028)	(0.147)	(0.052)	(0.077)	(1.128)		(.088)						
2. 58Q1-81Q4	0.502	0.041	0.066	0.391	0.322	0.288	-0.572	0.003	0.679	0.827	0.449	2.2	16.339	-0.036	0.531
	(0.129)	(0.032)	(0.034)	(0.139)	(0.048)	(0.067)	(0.960)		(.088)						
3. 62Q2-81Q4	0.375	0.063	0.049	0.552	0.313	0.222	-0.888	-0.038	0.774	0.837	0.412	2.4	10.858	-0.105	0.673
	(0.168)	(0.035)	(0.042)	(0.156)	(0.048)	(0.065)	(0.891)		(.109)						
4. 64Q1-81Q4	0.417	0.099	0.151	0.487	0.319	0.248	-1.036	-0.039	0.735	0.828	0.413	2.5	9.732	0.437	0.729
	(0.170)	(0.038)	(0.059)	(0.159)	(0.050)	(0.067)	(0.896)		(.112)						
5. 67Q1-81Q4	0.510	0.092	0.259	0.359	0.302	0.295	-0.989	-0.201	0.654	0.833	0.404	2.4	7.347	0.971	1.145
	(0.173)	(0.041)	(0.095)	(0.176)	(0.052)	(0.075)	(0.882)		(.120)						
6. 70Q3-81Q4	0.843	0.080	0.318	0.161	0.273	0.327	-1.047	-0.274	0.488	0.798	0.424	2.6	5.565	1.071	1.273
	(0.332)	(0.048)	(0.128)	(0.255)	(0.059)	(0.087)	(0.934)		(.193)						
7. 73Q4-81Q4	1.267	0.030	0.272	0.029	0.265	0.305	-1.155	-0.338	0.276	0.722	0.413	2.7	3.588	0.443	0.765
	(0.723)	(0.068)	(0.135)	(0.349)	(0.063)	(0.088)	(0.928)		(.325)						
8. 62Q2-70Q2	2.556	0.088	0.381	-1.425	0.220	-0.341	-	-	-1.766	0.550	0.312	2.1	2.047	-	-
	(1.098)	(0.049)	(0.165)	(1.136)	n.a.	(0.250)			(1.190)						
9. 62Q2-72Q4	1.016	0.065	0.156	0.186	0.185	-0.215	-	-	-0.029	0.591	0.327	2.0	3.10	-	-
	(0.600)	(0.043)	(0.086)	(0.643)	n.a.	(0.211)			(.596)						
10. 64Q1-72Q4	0.819	0.098	0.175	0.378	0.251	-0.194	-	-	0.184	0.577	0.331	2.2	2.635	-	-
	(0.646)	(0.053)	(0.092)	(0.696)	n.a.	(0.224)			(.644)						
11. 58Q1-66Q4	1.202	0.125	0.139	-0.619	-0.068	0.324	-	-	-0.295	0.518	0.383	2.4	3.516	-	-
	(0.403)	(0.053)	(0.061)	(0.582)	n.a.	0.304)			(.517)						

* Second degree Almon lag of order six (starting in period t for c' but t-1 for b') with no head or tail constraint.

** Second degree Almon lag of order four (starting in period t) with no head or tail.

*** Freely estimated two-period lag; standard error not available, approximated as the geometric average of the standard error of do and d1.

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